MICRO-EMULSION (NANOTECHNOLOGY) FUEL/ADDITIVE COMPOSITION

CIP Patent Application of Inventors:

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CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of US patent application Serial Number: 10/029,438, filed 24 December 2001; which is a continuation-in-part of 09/588,029, filed 5 June 2000, now abandoned; which is a continuation-in-part of 09/039,675, filed 16 March 1998, now abandoned; which is a continuation-in-part of 08/629,802, filed 10 April 1996, now abandoned; which is a continuation-in-part of 08/296,457, filed 26 August 1994, now abandoned; which is a continuation-in-part of 08/153,049, filed 17 November 1993 (parent application), now abandoned.

All of the disclosures in the prior applications are incorporated herein by reference in their entirety.

BACKGROUND – FIELD OF THE INVENTION

There exists a large body of prior art patents all concerned with fuel/water emulsions being used to improve the combustion of liquid hydrocarbon fuels. Almost exclusively, these distinguish amongst themselves by patentable differences between the surfactants and co-surfactants used to create these emulsions.

BACKGROUND - DESCRIPTION OF THE PRIOR ART

Water and lighter hydrocarbon fuels (gasoline and diesel) do not stay mixed long enough for combustion purposes and several strategies have been employed to achieve sufficient emulsion stability. US #6,607,566 Coleman teaches using a small quantity of emulsifying agent and significant mechanical agitation to create fuel macro-emulsions (having water droplets greater than 1.0 microns diameter). US #3,876,391 McCoy teaches fuel micro-emulsions (having water droplets smaller than 0.1 microns diameter) using significantly more emulsifying agents and less mechanical agitation.

Prior art water levels of 10,000 to 400,000 parts per million ("ppm") in the fuel is generally accepted as necessary to achieve any worthwhile improvement in combustion.

However, in order to achieve even short term fuel emulsion stability at these “high” water levels, significantly large quantities of “expensive” emulsifying surfactants are required (typically 5,000 to 200,000ppm). This surfactant expense always makes the cost/benefit ratio of this type of high water content fuel emulsion unsuitable for regular commercial applications. Typical of all this group of patents is US #4,744,796 Hazbun.

US #4,396,400 Grangette claims 1,000ppm of emulsified water (together with 500ppm of surfactant) gives the optimum improvement. Again, using 500ppm of surfactant would still make this fuel too expensive for most commercial applications.

Grangette also discloses that it is possible to produce “ultra-low” water content fuel emulsions by adding 100ppm of water, but employing only 25ppm of a single “crude” surfactant. With so much water and so little surfactant, the resulting fuel emulsion would not be stable enough for commercial applications. Grangette failed to realize that any ultra low water content fuel emulsion (about 100ppm added water) always requires significantly more “crude” surfactant than added water in order to remain stable over the required lifetime of the fuel (extra surfactants are required to emulsify the 50 to 100ppm dissolved water typically present in all commercially available liquid hydrocarbon fuels). This requirement has never been recognized and used by any prior art.

SUMMARY OF THE INVENTION - OBJECTS AND ADVANTAGES

Liquid hydrocarbon fuels intended for use in internal combustion machines are dosed at 20 to 500ppm with a micro-emulsion forming fuel additive. The resulting fuel composition has the object of improving fuel efficiency to such an extent that the invention can be employed in a significantly cost effective manner not previously realized by any prior art fuel emulsion. A further object is to reduce combustion exhaust emissions.

Still further objects and advantages will become apparent from consideration of the following description and examples.

DETAILED DESCRIPTION OF THE INVENTION

Fuel additive compositions are disclosed which can be mixed with liquid hydrocarbon fuels (such as gasoline, diesel fuel, and jet fuel) to form stable "water-in-oil" micro-emulsions. Improved combustion and fuel efficiency can be achieved by adding as little as 20 to 500ppm of the additive into these hydrocarbon fuels. This results in a fuel micro-emulsion containing only about 5 to 95ppm of added water. Long term stability of this low dose level micro-emulsion fuel (sufficient for most commercial applications) is achieved by using high surfactant to water ratios in the additive (from about 8:1 to 0.5:1, more preferably from about 3:1 to 1.5:1). Consequently, the additive usually employs significantly more surfactant than water (unlike any prior art).

Even if over time the micro-emulsion breaks down, the amount of water released is not large (typically 50ppm) and should easily be absorbed by the fuel. The expected fuel additive benefits may be lost but no damage to the engine should occur (which could lead to possible product liability claims).

Typical prior art fuel emulsions teach adding 5,000ppm of surfactant together with 10,000ppm water. This renders the background level of 50 to 100ppm dissolved water in the fuel totally insignificant to prior art. However, knowledge of this dissolved water content is absolutely critical to the successful application of the present invention. It is very important not to overwhelm the small amount of surfactant added to the fuel by expecting it to emulsify too much water (resulting in an unstable macro-emulsion).

When the fuel additive dose level becomes so low that the background quantity of dissolved water in the fuel approaches (or exceeds) the quantity of water employed in the fuel additive, then it is critical to increase the surfactant to water ratio in the present

additive to compensate for the extra water in the fuel. This allows for long term fuel emulsion stability (as the additive slowly emulsifies the dissolved water in the fuel).

There exists a cost/benefit threshold in emulsion fuels which cannot be crossed except by fuels dosed with less than about 500ppm of micro-emulsion forming fuel additive. With more than about 500ppm of additive, the process costs too much relative to the fuel savings. With less than about 20ppm of additive, there is generally too little surfactant present for the fuel emulsion to have any long term stability.

Fuel additives are produced by mixing together appropriate proportions of surfactant(s), co-surfactant(s) and water. Hydrocarbon solvents can also be included.

Generally, a minimum number of at least two surfactants would be required, each one acting against the other in order to achieve exactly the right HLB balance for the specific fuel to be treated. For a good explanation of this required surfactant HLB balance refer to US #3,876,391 McCoy.

When the additive is mixed with liquid hydrocarbon fuels a multitude of dispersed micro-emulsified water droplets are created, each droplet having an initial diameter from about 1.0 to 100 nanometers (0.001 to 0.1 microns), typically 3.0 to 9.0 nanometers. These dispersed micro-emulsified water droplets remain in stable suspension until such time as they are carried with the fuel into the combustion chamber.

Fuel additives of the present invention can be produced which are stable enough for most commercial applications. These severe "real world" applications require fuel emulsion stability from below - 40 deg C to over +80 deg C, not only as an additive but also as a diluted additive (for retail sales) and more particularly after dosing into the fuel.

TABLE 1 (Commercially Available Surfactants Used to Produce the Additives):

Trade Name	Chemical Name	Type	Supplier
Arquad T-50	Trimethyl Tallow Alkyl Quat	Cationic	Akzo Nobel
Aristonate "M"	Sodium Alkyl Aryl Sulfonate	Anionic	Pilot

Aristonate "L"	Sodium Alkyl Aryl Sulfonate	Anionic	Pilot
Chembetaine CAS	Cocoamidopropyl Hydroxysultaine	Amphoteric	Chemron
Hamposyl C-30	Sodium Cocyl Sarcosinate	Anionic	Hampshire
Makon 4	Ethoxylated Alkylphenol	Non-ionic	Stepan
Makon 8	Ethoxylated Alkylphenol	Non-ionic	Stepan
Norfox TLS	Triethanolamine Lauryl Sulfate	Anionic	Norman Fox
Ninate 411	Amine Alkylbenzene Sulfonate	Anionic	Stepan
Span 80	Sorbitan Monooleate	Non-ionic	ICI
Surfonic L24-4	Linear Alcohol Ethoxylate	Non-ionic	Huntsman
Surfonic L24-9	Linear Alcohol Ethoxylate	Non-ionic	Huntsman
Ninate 411	Amine Alklybenzene Sulphonate	Non-ionic	Stepan
Tween 80	POE (20) Sorbitan Monooleate	Non-ionic	ICI
Pamak W4	Tall Oil Fatty Acid	Non-ionic	Hercules
Norfox IM 38	Oleyl Imidazoline Hydrochloride	Cationic	Norman Fox
Norfox F-221	Oleamide Diethanolamine	Non-ionic	Norman Fox

COMMENTS ON CO-SURFACTANTS USED IN THE ADDITIVES

All co-surfactants used to produce the additives should be well recognized by those skilled in the art and are readily available from many industrial sources. For this reason, trade names and suppliers have been omitted for these components.

Although specific alcohols have been named as being suitable co-surfactants, other low molecular weight alcohols (either alone or in combination) could also be used.

Although specific glycols have been named as being suitable co-surfactants, other low molecular weight glycols (either alone or in combination) could also be used.

Also, certain glycol ethers have been employed in combination with low molecular weight alcohols to form strong coupling agents well known to those skilled in the art. Specifically, these glycol ethers can be obtained from Dow Chemical under the

trade names Dowanol DPM (dipropylene glycol methyl ether) and Dowanol EB (ethylene glycol n-butyl ether). Although these two glycol ethers have been specifically named as being suitable co-surfactants, other glycol ethers might also be suitable.

COMMENTS ON HYDROCARBON SOLVENTS USED IN THE ADDITIVES

Although kerosene was used as the hydrocarbon (HC) solvent when making certain of the fuel additives, those skilled in the art will realize that other hydrocarbon solvents (including oxygenated hydrocarbons) could easily be used instead of kerosene. Specifically, aliphatic, aromatic or paraffinic hydrocarbons (either alone or in combination) could also be used.

PRODUCING THE FUEL ADDITIVES (Examples #1 to #20)

When mixing together the surfactant(s), co-surfactant(s), water and hydrocarbon (HC) solvent to produce the micro-emulsion forming additives used in these examples, the following technique was used:

1) For those additives containing a hydrocarbon solvent, this was the first ingredient.

2) Alternatively, the co-surfactant(s) was either the next or the first ingredient.

3) Then the surfactant(s) was added using gentle stirring.

4) Finally, the water was added slowly with gentle stirring until the resulting additive was clear and stable. Regular city water (not distilled water) was used in all examples.

5) All ratios, ppm's and percentages used herein and elsewhere are by weight.

EXAMPLES OF THE INVENTION (Additives #1 to #12)

All fuel additives disclosed in the following examples (#1 to #12) deliberately use various combinations of already existing and commercially available surfactants and co-surfactants. This has been done to clearly demonstrate that these additives should not be limited to any particular combination of specific surfactant(s) and co-surfactant(s). Each

of the examples (#1 to #12) employs only 50ppm water and uses the high surfactant to water ratio (up to 8:1) necessary for long term fuel emulsion stability.

There must be many such additives possible (using different combinations of other surfactants and co-surfactants) that could also be used to produce similar micro-emulsion forming fuel additives. Reference is made specifically to (US #4,744,796 Hazbun) which clearly demonstrates that various (equally effective) micro-emulsion fuels can be produced using diversely different types of surfactant and co-surfactant combinations.

These other combinations might be better (or worse) than the specific examples which follow. Some may have better high (or low) temperature stability, or have improved pour point, flash point, cost, viscosity, corrosiveness, commercial availability, toxicity, freezing point, color, smell, legislative acceptability, or any number of other particular benefits depending on the balance of importance prevailing at the time.

Therefore, it is not critical which specific surfactant or co-surfactant combinations are used, provided that they are adequate. Different combinations may be better than others in some way or another, but it is essentially the use of a cost effective ultra low treat rate (20 to 500ppm) micro-emulsion forming fuel additive (having a high surfactant to water ratio) which is crucial to the practical application of the present invention.

TABLE 2 (Component Percentage Composition for Additive Examples #1 to #12):

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
HC Solvent (Kerosene)	-	-	-	-	-	-	20	30	-	20	20	-
Arquat T-50	-	-	-	-	-	-	-	-	-	-	-	20
Aristonate "M"	-	35	-	-	-	-	-	-	-	-	-	-
Aristonate "L"	-	25	-	-	-	-	-	-	-	-	-	-
Chembetaine CAS	-	-	-	-	-	-	-	-	-	-	10	-
Hamposyl C-30	-	-	-	-	4	-	-	-	-	-	-	-

Makon 4	-	-	-	-	-	20	-	20	-	30	-	-
Makon 8	-	-	-	25	-	10	-	10	-	30	-	-
Norfox TLS	-	-	-	-	-	-	7	-	-	-	-	-
Ninate 411	70	-	-	-	-	30	-	30	30	-	60	-
Span 80	-	-	-	55	66	-	53	-	50	-	-	50
Surfonic L24-4	-	-	40	-	-	-	-	-	-	-	-	-
Surfonic L24-9	-	-	40	-	-	-	-	-	-	-	-	-
Methanol	-	-	10	-	-	-	-	-	5	-	-	-
Ethanol	-	-	-	10	10	-	-	-	-	-	-	-
Iso-Propanol	20	-	-	-	-	20	10	-	-	-	-	20
2-Butanol	-	20	-	-	10	-	-	-	-	-	-	-
Ethylene Glycol	-	-	-	-	-	-	-	-	-	10	-	-
Propylene Glycol	-	-	-	-	-	-	-	-	5	-	-	-
Water	10	20	10	10	10	20	10	10	10	10	10	10
Total (%)	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 3 (Analysis of Component Percentage for Additive Examples #1 to #12):

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
HC Solvent (Kerosene)	-	-	-	-	-	-	20	30	-	20	20	-
Surfactant(s)	70	60	80	80	70	60	60	60	80	60	70	70
Co-surfactant(s)	20	20	10	10	20	20	10	0	10	10	0	20
Water	10	20	10	10	10	20	10	10	10	10	10	10
Total (%)	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 4 (Additive Dose Ratio and Component ppm's in Fuel for Examples #1 to #12):

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Hydrocarbon fuel	Gas	#2D	Gas	#2D	Gas	Gas	Gas	Gas	#2D	Gas	#2D	Gas

Dose Ratio	2K	4K	2K	2K	2K	4K	2K	2K	2K	2K	2K	2K
Kerosene	0	0	0	0	0	0	100	150	0	100	100	0
Surfactant(s)	350	150	400	400	350	150	300	300	400	300	350	350
Co-surfactant(s)	100	50	50	50	100	50	50	0	50	50	0	100
Water	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>
Total ppm in fuel	500	250	500	500	500	250	500	500	500	500	500	500
Treat cost/gal	55	17	51	95	99	25	89	52	88	42	56	100

Note: (a) Dose ratio 2K = 2,000:1 and 4K = 4,000:1.

(b) Dose ratio used was based on the relative emulsifying ability of the particular additive surfactant/co-surfactant combination. Some additives were much stronger than others, and could be used at a lower dose rate.

(c) For comparison purposes, relative treatment cost/gallon are all based on example #12 (the most expensive) being given the arbitrary value of 100.

<u>TABLE 5 (Analysis of Component ppm's in Fuel for Additive Examples #1 to #12):</u>

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
HC Solvent	0	0	0	0	0	0	100	150	0	100	100	0
Surfactant(s)	350	150	400	400	350	150	300	300	400	300	350	350
Co-surfactant(s)	100	50	50	50	100	50	50	0	50	50	0	100
Water	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>	<u>50</u>
Additive in Fuel:	500	250	500	500	500	250	500	500	500	500	500	500
Hydrocarbon Fuel:	----------------- Balance up to 100% (1,000,000ppm) -----------------											
Surf/Water Ratio	7:1	3:1	8:1	8:1	7:1	3:1	6:1	6:1	8:1	6:1	7:1	7:1

FURTHER EXAMPLES OF THE INVENTION (Additives #13 to #20)

In previous examples #1 to #12 only one or two surfactant(s) have been used in combination, consequently forming relatively "crude" fuel additives. Those skilled in the

art of surfactant chemistry should easily be able to improve the efficiency of the surfactant(s) and co-surfactant(s) combination. These more "sophisticated" additives would require less surfactant per unit of water and hence significantly improve the overall cost effectiveness of the fuel additive.

Examples #1 to #12 require surfactant to water ratios of typically 7:1 in order to produce sufficiently stable fuel emulsions. However, when using these more "sophisticated" surfactant packages, this ratio could be reduced to 3:1 or less (sometimes much less).

Therefore, examples #13 to #20 which follow are used to clearly demonstrate how these more "sophisticated" chemical packages can significantly reduce the total quantities of surfactants required, and hence improve the cost effectiveness of the additive, while still remaining sufficiently stable for most commercial applications.

TABLE 6 (Component Percentage Composition for Additive Examples #13 to #20):

	#13	#14	#15	#16	#17	#18	#19	#20
Hydrocarbon Solvent (Kerosene)	-	-	-	16.7	-	-	-	-
Amine alkylbenzene sulphonate	21.3	21.3	21.3	26.7	21.2	21.4	27.4	22.2
POE (20) sorbitan monoleate	10.4	10.4	10.4	3.3	7.7	12.9	16.5	2.2
Tall oil fatty acids	9.2	9.2	9.2	6.6	15.3	5.3	6.8	-
Oleyl imidazoline hydrochloride	4.8	4.8	4.8	-	-	6.4	8.2	-
Oleamide diethanolamine	8.0	8.0	8.0	13.3	7.7	10.7	13.6	4.5
Methanol	18.0	18.0	18.0	-	-	16.1	20.6	-
Iso-propanol	-	-	-	16.7	14.3	-	-	-
N-butanol	-	-	-	-	-	-	-	11.6
Ethylene glycol n-butyl ether	3.2	3.2	3.2	-	-	4.3	5.5	-
Dipropylene glycol methyl ether	0.7	0.7	0.7	-	-	1.1	1.4	2.3
Water	24.4	24.4	24.4	16.7	33.8	21.8	00.0	57.2

Total(%)	100	100	100	100	100	100	100	100

TABLE 7 (Analysis of Component Percentages for Additive Examples #13 to #20):

	#13	#14	#15	#16	#17	#18	#19	#20
Hydrocarbon Solvent	0	0	0	16.7	0	0	0	0
Surfactant(s)	53.7	53.7	53.7	49.9	51.9	56.7	72.5	28.9
Co-surfactant(s)	21.9	21.9	21.9	16.7	14.3	21.5	27.5	13.9
Water	24.4	24.4	24.4	16.7	33.8	21.8	00.0	57.2
Total (%)	100	100	100	100	100	100	100	100

TABLE 8 (Dose Ratio and Component ppm's in the Fuel for Examples #13 to #20):

	#13	#14	#15	#16	#17	#18	#19	#20
Hydrocarbon Fuel	Gas	Gas	Gas	Gas	Gas	#2D	#2D	Gas
Additive Dose Ratio	7.5K	12K	50K	4K	4K	10K	10K	6K
Kerosene	0	0	0	42	0	0	0	0
Surfactant(s)	72	45	11	124	130	57	72	48
Co-surfactant(s)	29	18	4	42	35	21	28	23
Water	32	20	5.0	42	85	22	0.0	95
Total ppm in fuel	133	83	20	250	250	100	100	166
Treatment cost/gal	11	7	2	23	18	9	11	7

TABLE 9 (Analysis of Component ppm's in the Fuel for Examples #13 to #20):

	#13	#14	#15	#16	#17	#18	#19	#20
Hydrocarbon Solvent	0	0	0	42	0	0	0	0
Surfactant(s)	72	45	11	124	130	57	72	48
Co-surfactant(s)	29	18	4	42	35	21	28	23
Water	32	20	5.0	42	85	22	0.0	95

Total Additive in fuel:	133	83	20	250	250	100	100	166
Hydrocarbon Fuel:	-------------- Balance up to 100% (1,000,000ppm) -----------							
Surfactant/Water Ratio	2.2:1	2.2:1	2.2:1	3:1	1.5:1	2.6:1	N/A	0.5:1

TABLE 10 (Component Ratios, ppm's in Fuel and Percentages for Examples #1 to #20):

Liquid	Ratio (Preferred)	Ratio (Range)
Surfactant(s)	3.0 to 1.5	8.0 to 0.5
Co-surfactant(s)	1.0 to 0.4	2.0 to 0.0
Water (= 1.0)	1.0	1.0

Liquid	ppm (Preferred)	ppm (Range)
Surfactant(s)	48 to 130	11 to 400
Co-surfactant(s)	21 to 42	0 to 100
Water	20 to 85	5 to 95

Liquid	% (Preferred)	% (Range)
Surfactant(s)	49.9 to 72.5	28.9 to 80.0
Co-surfactant(s)	13.9 to 21.9	0.0 to 27.5
Water	16.7 to 33.8	10.0 to 57.2

VEHICLE TEST RESULTS (Using Fuels Dosed with Additive Examples #1 to #20)

In examples #1 to #20 fuels dosed with ultra low treat rate micro-emulsion fuel additives were tested to look for benefits similar to those claimed in the "high" water content emulsion fuel prior art (typically reduced engine exhaust emissions).

No laboratory engine testing was carried out. Actual vehicles were used in "over the road" testing. Seven completely different test vehicles were used. Three were

gasoline powered and four were diesel powered. Two were from USA, three from Europe, and two from Japan. Ages, mileages and emission control technologies were also widely different.

TABLE 11 (Emission % Reduction and Mileage % Increase Using Additives #1 to #20)

Additive #	HC	CO	NOx	PM	MPG	Relative Cost
1	20	--	--	--	10	55
2	--	--	5	15	6	17
3	60	--	--	--	10	51
4	--	--	3	6	--	95
5	6	--	--	--	4	99
6	50	--	--	--	10	25
7	90	--	--	--	2	89
8	45	--	--	--	5	52
9	--	--	6	23	2	88
10	40	--	--	--	10	42
11	--	--	5	18	6	56
12	50	--	--	--	10	100
13	13	10	36	--	--	11
14	80	--	--	--	10	7
15	50	--	--	--	2.5	2
16	52	85	1	--	12	23
17	98	+35	95	--	--	18
18	49	--	9	22	14	9
19	--	--	5	15	--	11
20	90	--	--	--	10	7

For exact details of the testing protocols used, including additive formulations, test vehicle details, testing equipment employed and specific results obtained, refer to Patent Application #10/029,438 dated 24 December, 2001 (now abandoned, but incorporated herein for reference purposes).

The unusual, surprising and unexpected results obtained when using the ultra low dose rate fuel additive of the present invention is the significant improvement in fuel economy (coupled with reduction in exhaust emissions) which allows the invention to be employed in a cost effective manner not realized by any prior art fuel emulsions.

COMMENTS ON FUEL/ADDITIVE TESTING (Examples #1 to #20)

It is obvious from the test results that some additives are much better than others in the critical ratio of performance to cost per gallon treated. It is this ratio that determines to a large extent the commercial acceptability of any given additive.

When comparing examples #1 to #20, clearly #18 would be the "best" diesel fuel additive and #20 would be the "best" gasoline additive (based simply on the cost/benefit ratio). However, this is seriously overly simplistic. When deciding whether one additive would be "better" than another, other factors must be considered. For example, additive #18 would probably be illegal in the USA because one of the surfactants contains chlorine.

With regard to the "best" co-surfactant to use, butanol usually gives the strongest emulsions because of its solubility compromise between water and hydrocarbon. However, for a commercially acceptable fuel additive, other factors such as flash point and freeze suppression must also be considered.

SUMMARY OF THE INVENTION

This invention relates to a micro-emulsion fuel/additive composition which reduces the exhaust emissions and improves the fuel economy of internal combustion

machines in a significantly cost effective manner not realized by any prior art fuel emulsion.

The fuel additive composition is intended to be used at a dose level of from about 20 to about 500ppm in a liquid hydrocarbon fuel (selected from the group consisting of gasoline, diesel fuel and jet fuel) combusted in internal combustion machines and should comprise, in admixture form: from about 10% to 57.2% (preferably 16.7% to 33.8%) of water; from about 28.9% to 80% (preferably 49.9% to 72.5%) of surfactant selected from the group consisting of non-ionic, anionic, cationic and amphoteric surfactants or combinations thereof (preferably a combination of amine alkylbenzene sulphonate, POE [20] sorbitan monooleate, tall oil fatty acids, oleyl imidazoline hydrochloride and oleamide diethanolamine); from about 0% to 27.5% (preferably 13.9% to 21.9%) of co-surfactant selected from the group consisting of low molecular weight alcohols, low molecular weight glycols and glycol ethers or combinations thereof (preferably methanol, ethanol, propanol, butanol, ethylene glycol, propylene glycol, ethylene glycol n-butyl ether and dipropylene glycol methyl ether or combinations thereof); and from about 0 to about 30% (preferably 0%) of hydrocarbon solvent (preferably kerosene).

When the above fuel additive is used in a liquid hydrocarbon fuel at a dose level from about 20 to 500ppm (preferably 83 to 250ppm), this results in a micro-emulsion fuel composition comprising: from about 999,500 to 999,980ppm (preferably 999,750 to 999, 917ppm) of hydrocarbon fuel (selected from the group consisting of gasoline, diesel fuel, and jet fuel); from about 11 to 400ppm (preferably 48 to 130ppm) of surfactant selected from the group consisting of non-ionic, anionic, cationic and amphoteric surfactants or combinations thereof (preferably a combination of amine alkylbenzene sulphonate, POE [20] sorbitan monooleate, tall oil fatty acids, oleyl imidazoline hydrochloride and oleamide diethanolamine); from about 0 to 100ppm (preferably 21 to 42ppm) of co-surfactant selected from the group consisting of low molecular weight alcohols, low molecular weight glycols and glycol ethers or combinations thereof (preferably methanol,

ethanol, propanol, butanol, ethylene glycol, propylene glycol, ethylene glycol n-butyl ether and dipropylene glycol methyl ether or combinations thereof); from about 0 to 150ppm (preferably 0ppm) of hydrocarbon solvent (preferably kerosene); and from about 5 to 95ppm (preferably 20 to 85ppm) of added water, such that the ratio of surfactant to added water falls within the range from about 8:1 to about 0.5:1 (preferably about 3:1 to 1.5:1).

SCOPE OF THE INVENTION

While only a few embodiments of the invention have been shown and described herein, it will become apparent to those skilled in the art that various modifications and changes can be made in the present invention to the present fuel/additive composition to produce fuel/additive micro-emulsions with a liquid hydrocarbon fuel without departing from the spirit and scope of the present invention. All such modifications and changes coming within the scope of the appended claims are intended to be carried out thereby.